(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : 0 649 267 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number : 94306920.3

(22) Date of filing : 21.09.94

(51) Int. Cl.[6] : H04Q 9/00

(30) Priority : 04.10.93 US 130965

(43) Date of publication of application : 19.04.95 Bulletin 95/16

(84) Designated Contracting States : DE FR GB IT

(71) Applicant : AT & T Corp.
32 Avenue of the Americas
New York, NY 10013-2412 (US)

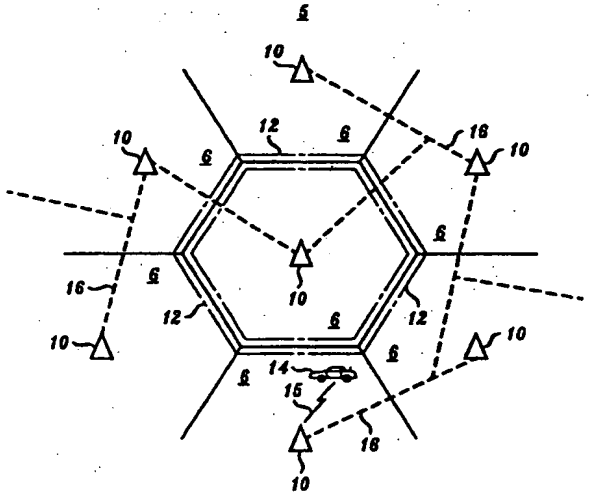
(72) Inventor : Haas, Zygmunt
4 Williams Way
Holmdel, New Jersey 07733 (US)
Inventor : I, Chih-Lin
9 Taylorr Lake Court
Manalapan, New Jersey 07726 (US)

(74) Representative : Buckley, Christopher Simon Thirsk et al
AT&T (UK) LTD.,
AT&T Intellectual Property Division,
5 Mornington Road
Woodford Green, Essex IG8 0TU (GB)

(54) A packetized cellular system.

(57) A packetized cellular system (5) in which a mobile (14) quasi-periodically transmits a beacon signal containing an ID number to a first base station (10) in the cell (6) in which it is located for storage with the ID's of other active mobiles in the cell. A copy of a list of the active mobiles in that cell is transmitted to all adjacent cells (6) where they are placed on an non-active list. Control of a mobile is handed-off to a second base station (10) upon the receipt of a transmitted ID number of the mobile at the second base station (10). The mobile is then listed as active in the database of the second base station and non-active in the first base station.

FIG. 1



EP 0 649 267 A2

Field of the Invention

The instant invention is directed to a packetized, cellular system. In particular, it relates to such a system that requires a limited amount of real-time processing to determine the association of a mobile with a base station for channel assignments and hand-off purposes.

Background of the Invention

There is increasing interest in wireless data communications, such as mobile computing, wireless messaging, facsimile, file transfer, and database access. Together with the trend of untethering computers from the desktop and the desire for universal connectivity, packetized cellular communications is becoming more and more important, and is being considered as the third generation of wireless networks.

Typical cellular networks are comprised of a large number of base stations. Each base station has an assigned coverage area (i.e. cell). In order for a mobile terminal to initiate a call, the cellular phone of the mobile is powered on and it scans the frequencies of a group of control channels for the strongest reception available. Once the appropriate control channel has been selected there is an exchange of messages between the base station and the mobile phone wherein the called terminal number is forwarded to the base station and a transmission channel is allocated to the mobile phone.

Undesirably, such a procedure requires that the mobile handset has the capability to : (1) scan a band of frequencies, (2) make power measurements, and (3) transmit the power measurements to the base station. Substantial functionality in the handset is required. Accordingly, there is a need for a technique that minimizes such processing to increase the efficiency of the mobile terminal.

Additionally, during an active communication, a mobile terminal that is leaving the coverage area of one base station must be "handed-off" to the next base station, whose coverage is the one the mobile is entering. In existing circuit switched systems this hand-off process is done via continuous communications between the base station and the mobile. Such a technique has its own system-level switching and control capability - a higher layer in the mobile network, operating above the individual cells. Through continuous, real-time measurements and comparisons of the signal strength received from the individual base stations, the mobile may initiate the handing-off of its call in progress to another cell. Such switching of a call is done "on-the-fly" without dropping or disrupting the call in progress. In general, substantial overlap in coverage areas between adjacent cells is required to insure high quality reception during hand-offs.

Unfortunately, such a hand-off technique may not be effective in a packet switched wireless system, due to the intermittent or bursty nature of the data traffic. Accordingly, there is a need for an effective hand-off procedure for use in packet switched wireless systems.

Additionally, future mobile platforms may be battery power and computation power limited. Thus, simpler procedures that reduce the amount of processing by the mobile platform may be required.

Summary of the Invention

The foregoing problems are overcome by the instant technique which is characterized by transmitting a quasi-periodic beacon signal containing ID information from active mobiles to a base station for storage in a database list therein. The database list of the ID information of the active mobiles is periodically transmitted from each base station to all base stations in adjacent cells for storage therein on a non-active mobile list. Also, control of a mobile moving from a first cell to a second cell is handed-off from a base station in the first cell to a second base station, in an adjacent cell into which the mobile is moving, upon the receipt of the beacon signal of the mobile at the second base station.

Additionally, in a packetized cellular system, the instant technique may be used for the purpose of resource (i.e. transmission channel) allocation. A mobile requiring a number of data slots on a transmission channel may also transmit a request for an allocation of that number of slots along with the ID information on the beacon signal. Upon receipt of such a request the base station will reserve the slots on the selected transmission channel.

In the Drawings

Fig. 1 depicts a cellular network in which the instant invention is implemented.

Detailed Description of The Invention

Fig. 1 depicts a portion of an exemplary cellular system 5. The system 5 is typically comprised of a plurality of cells 6, each having a single base station 10 located therein. Any two adjacent cells 6 overlap in an "overlap" area 12. A mobile 14 (i.e. vehicle, airplane, hand-held portable, etc.) is any unit able to physically move from one location to another, which is capable of communicating to a base station 10 via a wireless link 15. The base stations 10 are interconnected by a terrestrial network 16.

In prior art systems, when a call is initiated the mobile 14 scans the frequencies of a group of control channels, transmitted by the base station 10, for the strongest reception available. Once a control channel

has been selected there is an exchange of messages between the base station 10 and the mobile 14 wherein the called terminal number is forwarded to the base station over the wireless link 15. The base station 10 is connected to the destination terminal by the terrestrial network 16, wireless links 15 or both.

When the mobile 14 moves from the coverage of a first cell 6, having a base station 10 to a second cell 6 having a second base station 10 it is necessary to hand-off control of the call to the second base station. Such hand-offs may occur repeatedly as a mobile 14 moves through the cellular wireless system 5. Existing systems execute these hand-offs by using their own physical and system-level switching and control capability - a higher layer in the mobile network, operating above the individual cells 6. For example the signal strength of a transmission in progress from the mobile 14 received at the first base station 10 is continuously measured by the mobile and compared to a predetermined threshold value. If the received signal level is below this threshold, the mobile 14 will scan the control channels to determine which is the strongest received base station 10 and initiate a hand-off to that base station. The call can then be switched from the first cell 6 to the second cell 6 "on-the-fly" without dropping the call in progress.

Although such a technique works well when monitoring relatively long continuous calls in progress, it is less effective in a packet switched system due to the bursty or intermittent nature of a data traffic call in progress. Accordingly, there is a need for a technique that is effective when hand-offs of data type traffic calls are required.

The instant packetized, cellular system 5 permits free roaming of mobiles 14 among cells 6 throughout the total coverage area. A mobile 14 can be either in the powered or "on" state or in the power "off" state, referred to herein as "active" and "non-active", respectively. When in the active state the mobile 14 is associated with an ID number. Each user is allocated a worldwide unique ID. These ID numbers can be, for example, similar to telephone numbers, or can be comprised of the user's home Internet Packet (IP) address, concatenated with a user login. The ID number need not be fixed to a mobile 14 but the ID of the mobile 14 can change based upon the mobile's current user (i.e. the mobile assumes the user's ID). Thus, in the instant system, ID numbers identify people and not only terminal devices. When more than one user is associated with the same mobile 14 that mobile may be assigned a special ID.

The present hand-off scheme uses a separate, universal signaling channel (S-channel) that is continuously monitored by every base station 10. The S-channel is a control channel which is used to establish, maintain, update and terminate the associations of the mobiles 14 with the base stations 10. Once such associations are created, there is a separate set of transmission channels that is used for the actual transfer of information, as well as for the set-up and termination procedures.

In the instant invention every active mobile 14 emits a beacon signal, on the S-channel, which includes it's ID information. The beacon transmission period has some built-in jitter. Such a beacon signal is referred to as "quasi-periodic" herein. In other words, the periodicity is "average periodicity". The jitter is required to eliminate correlation of collisions in order to avoid the situation where two colliding beacons will collide forever. The jitter should be on the order of several beacon transmission times. Thus, when the mobile 14 roams through the territory of a base station 10, the ID number of the mobile 14 is continuously being received by that base station.

When a mobile 14 has power on, an association with a base station 10 is created by the quasi-periodic beacon even when there is no calling connection set up. When the mobile 14 initiates a new connection, it signals to the base station 10 the requested destination, along with it's own ID number.

Using the ID numbers transmitted on the beacon each base station 10 maintains a database list of the mobiles 14 in its coverage area - called active mobiles. In addition, each base station 10 maintains in its database a list of all the active mobiles 14 in the neighboring cells 6 which are locally referred to as non-active mobiles. This information is made available by periodic dissemination of the list of active mobiles 14 in each base station 10 coverage area to its adjacent cells 6 through the terrestrial network 16. In addition to the list of the ID numbers of the active mobiles 14 in the coverage area of a base station 10 this information exchange also includes the address of the destinations of the connections (if such exist) of the active mobiles 14 in the coverage area of the base station and the transmission channel numbers associated with the active mobiles.

Also, in the instant technique the beacon signal can incorporate the number of slots required to accommodate the data to be sent over a transmission channel by a mobile 14. The base station 10 then allocates this number of slots in the selected transmission channel. Advantageously, this allocation technique can conserve substantial resources (i.e. transmission channels).

In operation, when a base station 10 receives an ID number and a call destination number of a mobile 14 from a neighbor cell 6 (in which the mobile is active) it sets-up a dormant connection to the call destination terminal. Thus, when the mobile 14 moves into the coverage area of the base station 10 (i.e. when the base station receives the mobile's beacon ID) it updates the status of the mobile 14 to active and assigns a channel to that mobile - the association between the mobile and the base station 10 has been created. A mobile 14 may be associated with more

than one base station 10 at the same time (e.g. when located in the overlap area 12). The hand-off mechanism is fully transparent to the mobile 14 which may not know what base station 10 it is associated with.

When a base station 10 fails to receive a beacon from an active mobile 14 for a period of "time-out", the base station 10 determines that the mobile 14 has left its coverage area. The ID number of the mobile 14 is then made non-active in the database and the connection to the mobile destination is also made dormant.

A mobile 14 may be considered active in more that one base station 10, while in the overlapping area 12. In this case, the mobile packets may be duplicated. It is the responsibility of the terrestrial network 16 to identify the duplicates and remove them from the network 5. In some cases, the end points (e.g. transport protocols) may need to eliminate the duplicates. The duplicates correspond to some inefficiency in the terrestrial network 16. However, since the terrestrial network 16 is not the capacity bottleneck, this inefficiency does not pose a significant disadvantage.

As herein before indicated a separate S-channel is used to continuously monitor every base station 10. An exemplary S-channel used in the instant system is based on transmission without coordination as in the ALOHA scheme which is described in detail in COMPUTER NETWORKS, by A.S. Tanenbaum, 1991, pages 253 to 265 and is incorporated by reference herein. However, in the instant technique it is not necessary to listen to the transmission to determine if the transmission was successful or not as in ALOHA. Briefly, the ALOHA scheme lets the users (i.e. mobiles) transmit whenever they have data to be sent. There will be collisions, of course, and the colliding packets will be destroyed. If the packet was destroyed, the sender waits a random amount of time and sends again. The waiting time must be random or the same packets will collide over and over, in lockstep.

It will be understood that the foregoing is merely illustrative of the principles of the invention and not for purposes of limitation. Various modifications can be made by those skilled in the art without departing from the scope and spirit of the instant invention. For instance, the beacon signal from each mobile 14 to the associated base station 10 may be transmitted only when the mobile is within a predetermined distance from the overlap area 12. Advantageously, such a technique will off-load a portion of the processing required of each mobile 14 and base station 10. The predetermined distance may be ascertained by measuring the signal power between the mobile 14 and the base station 10. When the power level falls below a predetermined level the quasi-periodic beacon signal is initiated. Alternatively, the bit-error rate of the signal can be monitored by the base station 10 and/or the mobile 14. A bit-error rate above a predetermined threshold would trigger the operation of the quasi-periodic beacon signal.

Claims

1. A packetized, cellular communication system having a plurality of cells with a partial overlapping coverage area with adjacent cells, each cell having a single base station therein, comprising:

   means for transmitting, quasi-periodically, a beacon signal containing ID information from active mobiles to a base station, for storage in a database list therein; and

   means for periodically transmitting copies of the list of the ID information of the active mobiles from a first base station to all base stations in cells located adjacent to the first cell for storage therein on a non-active mobile list.

2. The system as set forth in Claim 1 characterized by:

   means for handing-off control of a mobile from the first base station to a second base station, in an adjacent cell, into which the mobile is moving, upon the receipt of the beacon signal of the mobile at the second base station.

3. The system as set forth in Claim 1, wherein:

   the beacon signal contains the number of data slots of a transmission channel required to accommodate the packets to be transmitted from the mobile.

4. The system as set forth in Claim 1, wherein:

   the beacon signal is only activated when the mobile is within a predetermined distance from the overlapping coverage area.

5. The system as set forth in Claim 1, wherein:

   the beacon signal is transmitted over a separate S-channel.

6. The system as set forth in Claim 1, wherein:

   the beacon signal contains the call destination number in addition to the ID information.

7. A method of signaling between a mobile and a base station in a packetized cellular system having a plurality of cells with a partial overlapping coverage area with adjacent cells, each cell having a single base station therein, comprising the steps of:

   transmitting, quasi-periodically, a beacon signal containing ID information from active mobiles to a base station, for storage in a data base list therein; and

periodically transmitting copies of the list of the ID information of the active mobiles from a first base station to all base stations associated with cells located adjacent to the first cell for storage therein on a non-active mobile list

8. The method as set forth in Claim 7, characterized by:

updating the status of the mobile from the non-active to the active list in an adjacent base station, in a cell into which the mobile is moving, upon receipt of the beacon signal from the mobile at the second base station; and

handing-off control of the mobile from the first base station to the second base station.

9. The method as set forth in Claim 7, characterized by:

transmitting, on the beacon signal, ID information and the number of data slots of a transmission channel required to accommodate the packets to be transmitted from the mobile; and

allocating, by the base station, the required number of slots in a selected transmission channel.

10. The method set forth in Claim 7, which is characterized by:

transmitting the beacon signal only when the mobile is within a predetermined distance from the overlapping coverage area.

11. The method as set forth in Claim 7, characterized by:

transmitting the destination number of any call in progress by the mobile in addition to the mobile ID and data slot information, on the beacon signal, for storage in the database of the base station.

12. The method as set forth in Claim 11, characterized by:

forwarding the call destination number and ID information to all base stations, in adjacent cells, for storage therein.

13. The method as set forth in Claim 12 characterized by each adjacent base station:

setting up a dormant connection to the call destination of a non-active mobile having a call in progress.

14. The method as set forth in Claim 13, characterized by:

updating the status of the mobile to active in the database list of the second base station upon receipt of the beacon signal from the mobile at the second base station;

activating the dormant connection by the second base station to maintain the connection between the mobile and the call destination; and

updating the active connection by the first base station to a dormant connection.

15. The method as set forth in Claim 14, characterized by:

updating the status of the mobile in the database list of the first base station to non-active.

16. A method for handing-off control of calls in a packetized, cellular system, comprising the steps of:

transmitting, quasi-periodically, a beacon signal comprising ID numbers from each active mobile in a first cell to a first base station, located therein, for storage in a database list therein;

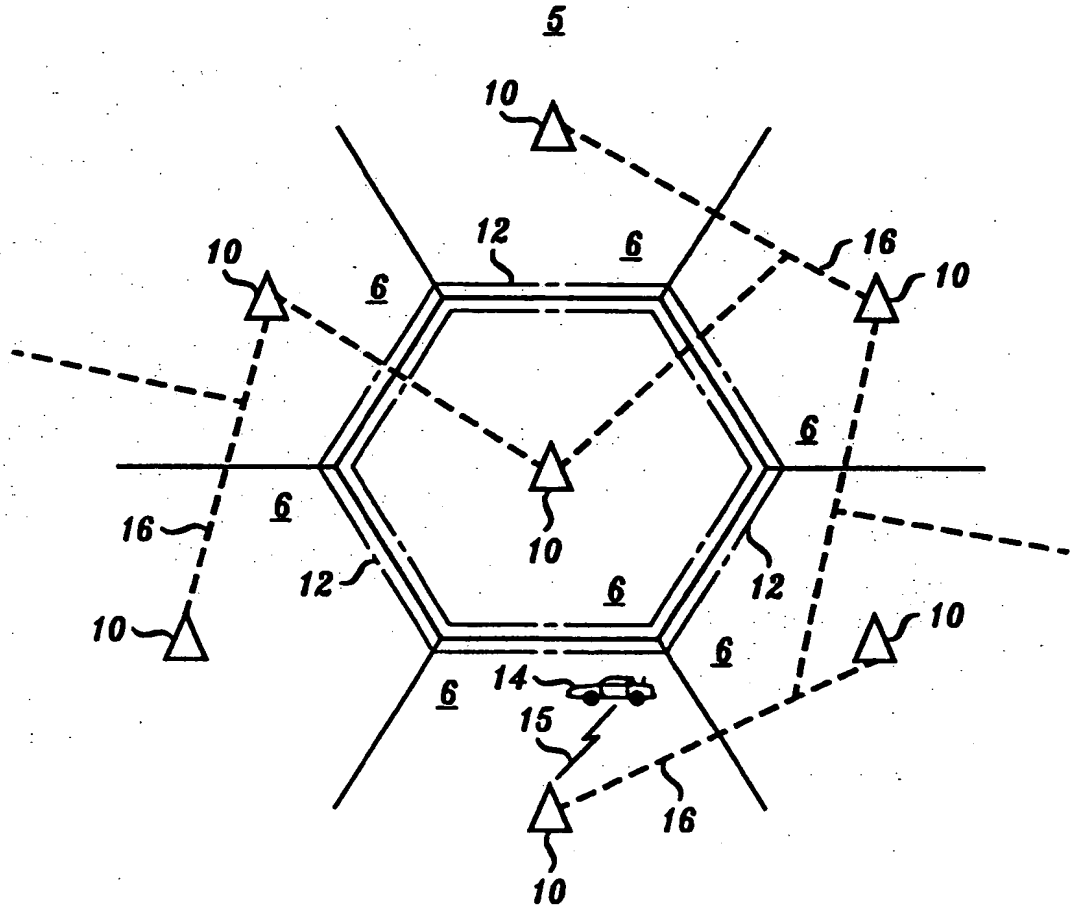
periodically transmitting copies of the active mobile ID list from the first base station to all base stations associated with cells located adjacent to the first cell

storing the list of ID numbers in the database of the base stations of each of the adjacent cells and characterizing the ID numbers as non-active;

receiving the beacon signal containing the ID number of the mobile at the second base station when the mobile moves into an overlapping area of coverage of the first and second cells; and

updating the list at the second base station to change the status of the mobile from non-active to active to transfer control of the mobile to the second base station.

FIG. 1



(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : 0 649 267 A3

(12) EUROPEAN PATENT APPLICATION

(21) Application number : 94306920.3

(22) Date of filing : 21.09.94

(51) Int. Cl.[6] : H04Q 7/22, H04Q 7/38, H04Q 9/00, H04B 7/26

(30) Priority : 04.10.93 US 130965

(43) Date of publication of application : 19.04.95 Bulletin 95/16

(84) Designated Contracting States : DE FR GB IT

(88) Date of deferred publication of search report : 12.07.95 Bulletin 95/28

(71) Applicant : AT & T Corp.
32 Avenue of the Americas
New York, NY 10013-2412 (US)

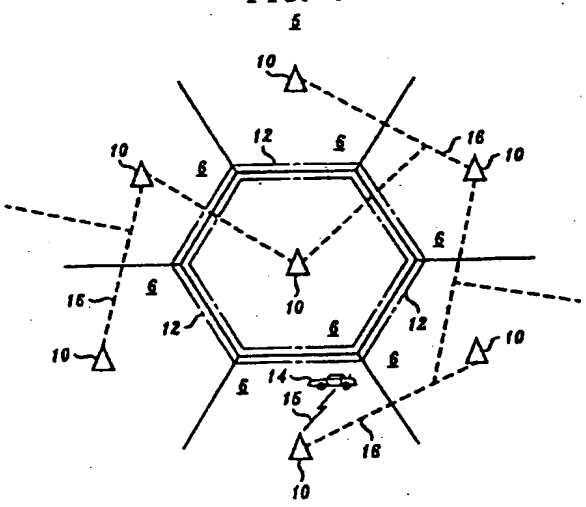
(72) Inventor : Haas, Zygmunt
4 Williams Way
Holmdel, New Jersey 07733 (US)
Inventor : I, Chih-Lin
9 Taylorr Lake Court
Manalapan, New Jersey 07726 (US)

(74) Representative : Buckley, Christopher Simon Thirsk et al
AT&T (UK) LTD.,
AT&T Intellectual Property Division,
5 Mornington Road
Woodford Green, Essex IG8 0TU (GB)

(54) A packetized cellular system.

(57) A packetized cellular system (5) in which a mobile (14) quasi-periodically transmits a beacon signal containing an ID number to a first base station (10) in the cell (6) in which it is located for storage with the ID's of other active mobiles in the cell. A copy of a list of the active mobiles in that cell is transmitted to all adjacent cells (6) where they are placed on an non-active list. Control of a mobile is handed-off to a second base station (10) upon the receipt of a transmitted ID number of the mobile at the second base station (10). The mobile is then listed as active in the database of the second base station and non-active in the first base station.

FIG. 1



EP 0 649 267 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 94306920.3

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.6)
A	WO - A - 92/10 914 (TELEFONAKTIEBOLAGET ERICSSON) * Abstract; page 1, line 1 - page 2, line 26; page 4, line 30 - page 9, line 18; fig. 1,2 *	1,2,7, 15	H 04 Q 7/22 H 04 Q 7/38 H 04 Q 9/00 H 04 B 7/26
A	EP - A - 0 522 772 (AMERICAN TELEPHONE AND TELEGRAPH) * Abstract; column 1, line 3 - column 4, line 36; column 8, line 13 - column 15, line 35; fig. 1-3,9 *	1,2,7, 15	
A	EP - A - 0 472 511 (TELEFONAKTIEBOLAGET ERICSSON) * Abstract; column 1, line 14 - column 3, line 57; column 4, line 17 - column 8, line 17; fig. 1-3 *	1,2,7, 15	TECHNICAL FIELDS SEARCHED (Int. Cl.6) H 04 Q H 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	28-04-1995	HAJOS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 639 036 A3**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **94305805.7**

(51) Int. Cl.[6] : **H04Q 7/38**

(22) Date of filing : **04.08.94**

(30) Priority : **12.08.93 GB 9316813**

(43) Date of publication of application :
15.02.95 Bulletin 95/07

(84) Designated Contracting States :
AT BE CH DE DK ES FR GB IT LI NL SE

(88) Date of deferred publication of search report :
12.07.95 Bulletin 95/28

(71) Applicant : **MacNamee, Robert Joseph Gerard**
20A High Street
Hinxton, Cambridgeshire CB10 1QY (GB)

(72) Inventor : **MacNamee, Robert Joseph Gerard**
20A High Street
Hinxton, Cambridgeshire CB10 1QY (GB)

(74) Representative : **Stone, Patrick**
28 Edenside Drive
Attleborough Norfolk NR17 2EL (GB)

(54) Cordless telephone handover system.

(57) A cordless telephone system in which a plurality of base-stations (1, 2, 3) provide coverage for handsets (5, 6) over overlapping areas, and transfer means (8, 9, 10, 11) are provided for performing handover from one base-station to another when it is detected that better communication between a handset in use can be established with a base-station alternative to that with which the handset is currently in communication.

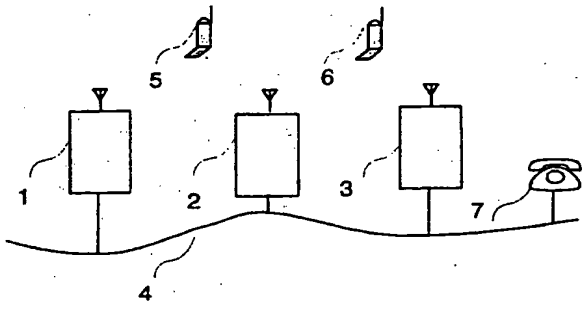


Fig.1a

EP 0 639 036 A3

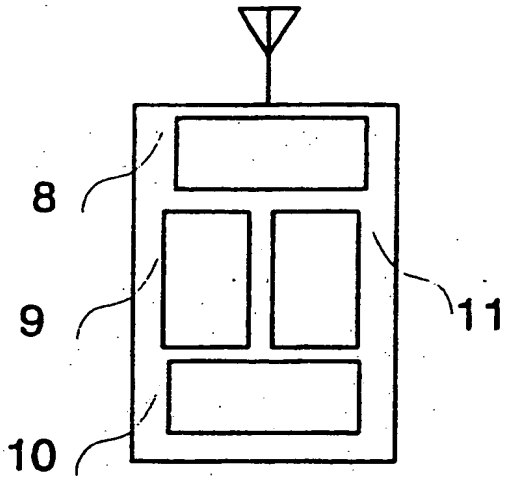


Fig.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 5805

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 283 683 (HITACHI) * page 2, line 40 - page 3, line 22 * * page 4, line 39 - page 5, line 1 * * page 10, line 34 - page 11, line 54; claims 10-12; figures 1,10 *	1-4,6-12	H04Q7/38
X	WO-A-92 13400 (ROGERS CABLE) * page 20, line 26 - page 22, line 9; figure 1 *	1-4,6	
X	ELECTRICAL COMMUNICATION, 30 June 1993, PARIS FR pages 172 - 180 WERBUS ET AL. 'DECT - Cordless Functionality in New Generation Alcatel PABXs' * page 173, right column, line 1 - page 174, left column, line 13 * * page 174, right column, line 52 - page 176, middle column, line 6 * * page 177, left column, line 29 - page 178, left column, line 11; figures 3-6 *	1-3,5, 8-12	
X	US-A-5 159 593 (D'AMICO ET AL.) * column 5, line 33 - line 62 *	1-3,5, 10-12	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04Q H04M
A	WO-A-92 17953 (MOTOROLA) * page 6, line 22 - page 8, line 25; figure 2 *	6	
A	WO-A-90 12469 (SIEMENS) * page 1, line 1 - page 2, line 5 * * page 7, line 25 - page 10, line 21; figure 1 *	8,11,12	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 May 1995	Janyszek, J-M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 5805

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	WO-A-94 05109 (MOTOROLA) * page 10, line 35 - page 16, line 7; figures 1,5-7 * -----	1-4,6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 May 1995	Janyszek, J-M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 639 036 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **94305805.7**

(22) Date of filing : **04.08.94**

(51) Int. Cl.[6] : ICM - H04Q007-38
PN - EP0639036 A 950215
EC - H04Q7/38H

(30) Priority : **12.08.93 GB 9316813**

(43) Date of publication of application :
15.02.95 Bulletin 95/07

(84) Designated Contracting States :
AT BE CH DE DK ES FR GB IT LI NL SE

(71) Applicant : **MacNamee, Robert Joseph Gerard**
20A High Street
Hinxton, Cambridgeshire CB10 1QY (GB)

(72) Inventor : **MacNamee, Robert Joseph Gerard**
20A High Street
Hinxton, Cambridgeshire CB10 1QY (GB)

(74) Representative : **Stone, Patrick**
28 Edenside Drive
Attleborough Norfolk NR17 2EL (GB)

(54) Cordless telephone handover system.

(57) A cordless telephone system in which a plurality of base-stations (1, 2, 3) provide coverage for handsets (5, 6) over overlapping areas, and transfer means (8, 9, 10, 11) are provided for performing handover from one base-station to another when it is detected that better communication between a handset in use can be established with a base-station alternative to that with which the handset is currently in communication.

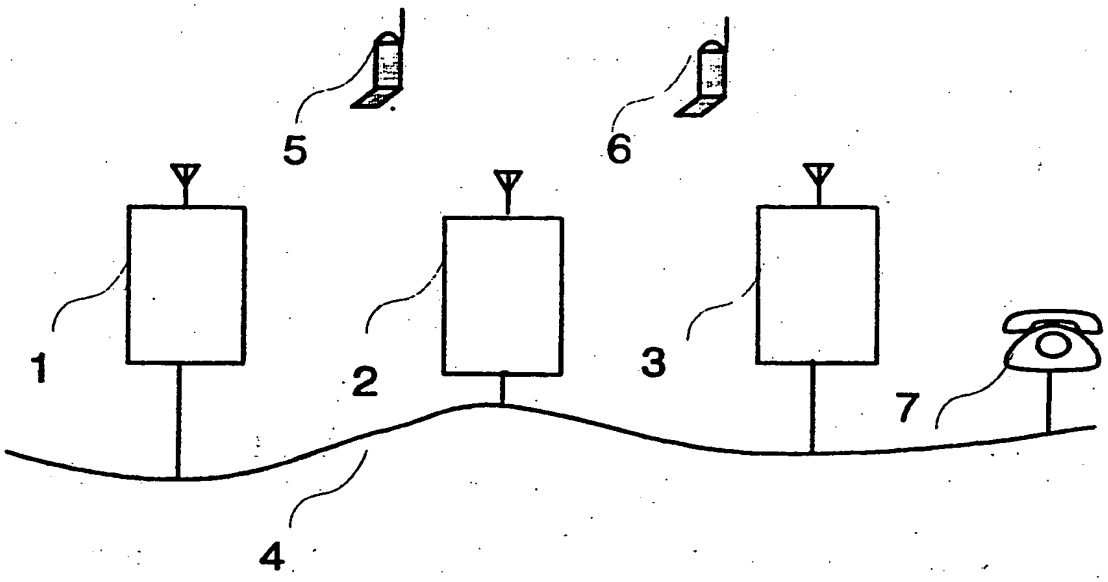


Fig.1a

EP 0 639 036 A2

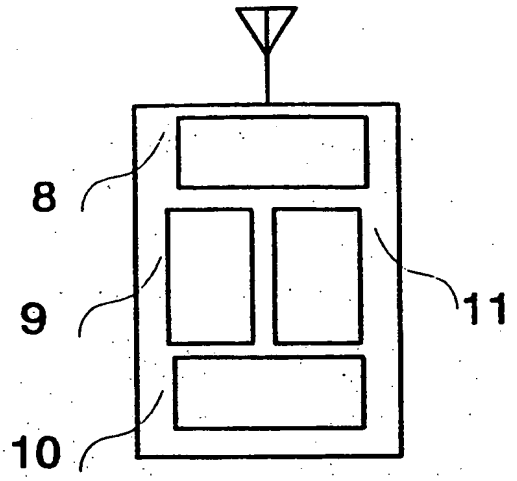


Fig.2

The present invention relates to cordless telephone systems and in particular to such a system comprising more than one base-station and providing for handover of a handset from one base-station to another.

Cordless telephones afford users the capability to make and receive calls within a radius of several tens or hundreds of metres of a radio base-station.

Examples of known cordless telephones comprise a primary station (Base Station or Cordless Fixed Part) connected via a radio link to a secondary station (Handset or Cordless Portable Part).

Two existing public standards for cordless telephone systems are CT2 and DECT.

DECT has 10 radio channels. Each radio channel is time division multiplexed into 12 user channels. There is a total of 120 channels. When the base-station is not transmitting other information, it transmits a reference signal. When a handset and base are in communication they exchange regular and frequent synchronisation and identity information.

CT2 has 40 radio channels. There is one user channel per radio channel. The base-station does not transmit any reference signals so the handset cannot tell in advance which base-station will offer the best quality. When the handset and base-station are in communication they do not exchange synchronisation information, except under fault conditions, and exchange identity information slowly.

Three common configurations of cordless telephone systems are: residential systems, office systems and public access systems.

Known residential systems typically comprise at least one handset and at least one base-station. The or each base-station is connected directly to the telephone network (PSTN). The or each base-station may have more than one handset registered to it, i.e. it may contain identity information for more than one handset. The or each handset may be registered to more than one base-station, i.e. it may contain identity information for more than one base-station. Each base-station is connected to one telephone line and incorporates one radio transceiver.

Known office systems comprise multiple radio base-stations connected to a central switching station. This provides a service for multiple users. Users may make or receive calls anywhere within the aggregate coverage area of the base-stations. When a user travels from the coverage area of one base-station to that of another, the system will handover the call from the original base-station to a destination base-station. This handover is determined by circuitry provided in the central switching station.

Handover, as the term is used herein, means the process of changing the radio base-station or radio channel which a handset is using, without releasing the call.

An object of the present invention is to provide a low cost handover technique especially but not exclusively applicable to residential systems.

According to the present invention there is provided a cordless telephone system having transfer means for performing handover of a handset from one to another of a plurality of base-stations connected to a common interconnection means, the transfer means comprising at each base-station means for acquiring knowledge of the signal quality of a handset with which it is in communication, means for signalling information via the common interconnection means if the acquired signal quality knowledge indicates that improved handset communication may be attainable, means for signalling a response via the common interconnection means, and means enabling handover to be effected if the signalling indicates that another base-station will have more favourable communication with the handset.

More particularly the system in accordance with the present invention comprises a plurality of autonomous base-stations connected to a common line or set of lines. All of the base-stations have equal status and the base-stations are typically located far apart from one another so that their respective coverage areas just overlap.

The invention may be practised in two different ways, one more suited to CT2 systems and one more suited to DECT systems.

In the former case, the means for acquiring knowledge comprises means at the base-station for measuring the signal quality of the handset with which it is in communication, and means enabling a handover to be effected if the response signal indicates more favourable communication between another base-station and the handset.

In a DECT system, the handset constantly monitors the qualities of communication with alternative base-stations and, if appropriate, requests a handover from a base-station offering more favourable communication, this alternative base-station then informing the existing base-station that it will take over the call, thereby to enable the existing base-station to release the call.

Each base-station has amongst other means:

- means for the measurement of the strength of radio signal received from a handset, or means for processing a measurement received from the handset,
- means for deciding whether or not the measured signal quality (at the base station or the handset) is

adequate,

- means for the transmission and reception of signalling messages,
- means for the comparison of two values, and
- means for deciding whether or not it should accept handover.

It will thus be appreciated that there are two strategies for initiating handover. In CT2 systems, base-station initiated handover is more appropriate, while in DECT systems handset initiated handover is more appropriate.

In handset originated handover, the handset requests handover from a more advantageous base-station, which alternative base-station sends a "command" message to the original base-station. This command message comprises at least a handset identifier signal.

In base-station initiated handover, when a call is in progress via one of the base-stations, and the quality of the received radio signal falls below a predetermined value, the said base-station will signal a "request" message on the common line or set thereof (common interconnection means).

This said request message preferably comprises two parts, an identifier and a value. The identifier may be either a radio channel number or a handset reference number. The value of the transmitted message is in direct proportion to the magnitude of the quality of the radio signal from the handset.

Each of the other base-stations which detect this request message and which is capable of responding, responds with a message whose value is in proportion to the magnitude of the quality of the radio signal received at that base-station from the handset. The other base-stations will preferably measure the received signal quality only of the entity referred to in the identifier field of the original base-station. Preferably only base-stations with a value of signal quality from the handset greater than that indicated by the original base-station will respond.

The originating base-station then compares the values of handset signal quality received back from the other base-stations with the value of handset signal quality transmitted in the request signal. If any of the received values is greater, the said base-station instructs the handset to begin handover. The base-station which transmitted the highest value of handset signal quality then completes the handover process.

The exact mechanisms for completing the handover process differ in different standards CT2, DECT. However, the mechanisms for executing the handover, once the decision to perform a handover has been taken, are generally known in the field of cordless communications and accordingly are not described. When the handover has been performed, the original base-station may maintain its connection to the common telephone line for a short time after the alternative base-station has also established its connection so as to ensure that there is no gap in the speech signal.

The present invention will now be further explained and described by way of example with reference to the accompanying drawings, in which:-

Figure 1a shows a cordless telephone system comprising multiple base-stations connected to a single common telephone line and associated portable handsets;

Figure 1b shows a cordless telephone system comprising multiple base-stations connected to multiple telephone lines;

Figure 2 shows the relevant functional blocks of each base-station;

Figure 3 shows the composition of a signalling messsage sent from the originating base-station to other base-stations; and

Figure 4 shows the architecture of a centrally controlled wireless PABX.

Referring to Figures 1a and 1b, the system comprises a plurality of geographically distributed base-stations 1, 2, 3. Each base-station is connected to at least one common shared telephone line (PSTN) 4. Each base-station is capable of radio communication with portable handsets 5, 6. Reference 7 indicates a fixed telephone on the same line.

Referring to Figure 2, each base-station comprises means 8 for measuring radio frequency signal quality, e.g. an analogue signal such as signal strength, or means for decoding measurements received from a handset, a controller means 9 for encoding this signal quality into a request signal if the quality value is below a predetermined threshold, means 10 for transmitting and receiving signalling information on the telephone line or lines 4, and means 11 for comparing the originally transmitted radio signal quality with quality values received back on the line or lines 4 from other base-stations, or means 11 for receiving and acting upon command messages received from other base-stations. The base-station also comprises means for performing other functions which are generally known in the field of cordless communication and accordingly are not described or illustrated.

The base-stations may be connected by one or more common lines. Each line may be analogue or digital. The lines may carry signalling or user traffic or both, although some circuits may be reserved for signalling. Some lines or circuits may be connected to the telephone network (PSTN or PABX) and others may be used solely for inter-connecting base-stations.

Possible means for the transmission of the signalling messages include multi-frequency tones, multi-frequency tones shifted in frequency so as to be ultra sonic, or RS232 or HDLC or ISDN digital signalling. The or each telephone line 4 may comprise either two wires (1 analogue circuit) or four wires (2 analogue circuits). Digital lines may support one or more circuit. If the base-stations 1, 2, 3 are connected to a line 4 with four wires then two may be used for the audio voice signal and two used for signalling and synchronisation purposes. If the base-stations 1, 2, 3 are connected to a line 4 with only two wires, then the signalling may be superimposed in common mode on the audio signal. If the base-stations are connected on an ISDN S-bus then the signalling may be carried in the D-channel.

During normal operation a handset user establishes a call via one of the base-stations. If the user begins to travel out of range of the radio base-station, then the radio signal strength and other measures of radio signal quality may fall below an acceptable threshold.

In handset controlled handover systems, when the handset requests handover to an alternative base-station, this alternative station signals the original base-station to inform it that the call will be continued on the alternative base-station, enabling the original base-station to release the call.

In base-station controlled handover, if the radio signal quality falls below an acceptable level, then the base-station sends a request message on the common signalling line to other base-stations.

This message comprises two fields, as indicated in Figure 3. These comprise an identifier field 12 and a value field 13. The identifier field 12 may be configured to refer to either a radio channel number or a handset reference number.

Base-stations which detect this request message then proceed to monitor and measure the radio channel quality of the entity specified in the value field. This is necessary because, in some systems, e.g. CT2, it would otherwise be difficult to monitor the transmissions of a specified handset since handset identity information is not transmitted with each burst.

Any base-stations which measure a better value of measured radio signal quality than that indicated by the originating base-station, then respond with a message containing the measured value of radio signal quality.

The identity field may optionally also contain a reference number for the base-station which transmitted it. The content of the value field 13 is proportional to the quality of the received radio signal.

There are two possible methods for avoiding responses colliding with each other.

According to one method for avoiding response collisions, responses are organised in time slots. Preferably the earliest time slots are reserved for responses with high value of signal quality and the latest timeslots for the weaker values of radio signal quality. If two base-stations do respond with the same radio signal quality value then there is a potential lockup problem. This can be resolved by adding random delay to each base-station's attempt to initiate a handover.

According to the other method of avoiding response collisions, each base-station delays a random period before beginning to monitor the line connecting the base-stations. If there are no other transmissions on the line, the base-station transmits its response. If there are other transmissions on the line, the base-station waits until these are finished, then waits another random interval, and rechecks whether the line is free or not. If when a base-station is waiting for a chance to respond it detects that another base-station is transmitting a quality value higher than it intends to transmit then it will refrain from transmitting.

The originating base-station indicates acceptance of a response by retransmitting that value of radio signal quality given in the response and optionally the identity of the base-station it has chosen to accept the handover. The original base-station then commands the handset to handover to the new base-station.

In both cases, i.e. handset originated and base-station originated handover, the connection to the new base-station may be effected before the original base-station is released.

The new base-station preferably should not request another handover for at least 10 - 20 seconds after a previous handover.

The means and method described above also provide a method for ensuring that when a call is set-up, it is connected to whichever base-station offers the better radio signal quality. When there is an incoming call signal on a common line to the base-stations, each base-station will attempt to call all handsets that it has been configured to call under these circumstances. The handset may "hear" call set-up messages from several base-stations and will respond to either the base-station that it hears first or to the base-station that has the strongest signal strength. Call set-up follows the known procedures and is then, if required, immediately followed by the handover procedure.

Preferably, in order for the method described above to work conveniently for the user, each base-station must contain subscription registration data on each handset that will be permitted to use the system. This is accomplished by using the signalling means to communicate the registration data which it contains to all other base-stations.

Using the method described above, the base-stations may be connected either in parallel or connected to a central switching station means. When all the base-stations are connected in parallel on, e.g. one analogue line, then when there is an incoming call on that line, there is no method of telling which handset the call is intended for and the base-station will cause all handsetsregistered on it to ring. This effectively limits the number of directly addressed users to one per common line. The base-station may be programmed so that only a specified handset "rings" in response to a ringing signal on a specified line. E.g. if there are 6 handsets and 6 lines connected to each base then when there is an incoming call on say line no. 1 only handset no. 1 will ring, or when there is an incoming call on line 4 then only handset no. 4 will ring.

Adding a central switching station, as shown in Figure 4, allows the addition of more incoming telephone lines than lines to each base-station and thus allows more users to the system. The central switching station has one incoming line for each user (or direct dial in facility). When a particular user calls in, the central switching station establishes which cell the called party is currently in and sets up the connection. When the base-stations are connected in parallel on a digital line, this line may permit sub-addressing, thereby to permit more than one user to be addressed directly on a single line.

When the signal quality falls below the acceptable level threshold, the base-station (any of 15 to 22) transmits a message. This message is detected by the central switching station 14. The central switching station 14 re-transmits this message to a number of other base-stations (the others of 15 to 22). These base-stations respond in the above-described manner. The central switching station may then decide which base-station should pick up the call and sends signalling messages to the originating and the destination base-stations. The handover is then executed.

Many cordless telephone standards use time division multiplexing or time division duplexing where handset and base-station communicate with each other on a common radio channel in alternate periods of time. Preferably the radio base-stations will be synchronised so that they all transmit only during the same period of transmission and receive only during the same period of reception. The synchronisation information may be deduced either from the structure of signals transmitted on the radio interface or from a clock signal transmitted on the telephone line. The clock information may be sent common mode on the voice circuit.

The clock information may be suspended intermittently to allow the transmission of signalling information on the same circuit.

If a second handset attempts to set up a call on a second base-station on the same line, then this may be inhibited when the base-station detects the presence of synchronisation clock information on the signalling line.

Claims

1. A cordless telephone system having transfer means for performing handover of a handset from one to another of a plurality of base-stations connected to a common interconnection means, the transfer means comprising at each base-station means for acquiring knowledge of the signal quality of a handset with which it is in communication, means for signalling information via the common interconnection means if the acquired signal quality knowledge indicates that improved handset communication may be attainable, means for signalling a response via the common interconnection means, and means enabling handover to be effected if the signalling indicates that another base-station will have more favourable communication with the handset.

2. A system according to claim 1, comprising a plurality of autonomous base-stations connected to a common line or set of lines each of which can support multiple circuits.

3. A system according to claim 2, wherein all the base-stations have equal status and the base-stations are typically located far apart from one another so that their respective coverage areas just overlap.

4. A system according to claim 1 or claim 2 or claim 3, wherein, in a CT2 system, the means for acquiring knowledge comprises means at the base-station for measuring the signal quality of the handset with which it is in communication, and means enabling a handover to be effected if the response signal indicates more favourable communication between another base-station and the handset.

5. A system according to claim 1 or claim 2 or claim 3, wherein, in a DECT system, the handset constantly monitors the qualities of communication with alternative base-stations and, if appropriate, requests a handover from a base-station offering more favourable communication, this alternative base-station then

informing the existing base-station that it will take over the call, thereby to enable the existing base-station to release the call.

6. A system according to claim 4 or claim 5, wherein each base-station includes
   - means for the measurement of the strength of radio signal received from a handset, or means for processing a measurement received from the handset,
   - means for deciding whether or not the measured signal quality (at the base-station or the handset) is adequate,
   - means for the transmission and reception of signalling messages,
   - means for the comparison of two values, and
   - means for deciding whether or not it should accept handover.

7. A system according to any of claims 3 to 6, wherein the request message comprises two parts, a handset identifier and a signal quality indicator value.

8. A system according to claim 2 or any claim appendant thereto, wherein a or each line or circuit may be arranged to carry signalling traffic only or voice traffic only.

9. A system according to claim 2 or any claim appendant thereto, wherein, for each base-station, certain lines are connected to the PSTN and other lines are solely for the interconnection of base-stations.

10. A system according to any of claims 1 to 9, having means enabling a call to be transferred to an alternative base-station before the telephone connection to the original base-station is released.

11. A system according to any of claims 1 to 10, wherein the subscription registration data is automatically exchanged between the base-stations using the signalling means.

12. A system according to any of claims 1 to 11, wherein the base-station may be programmed so that only a specified handset rings in response to a ringing signal on a specified line.

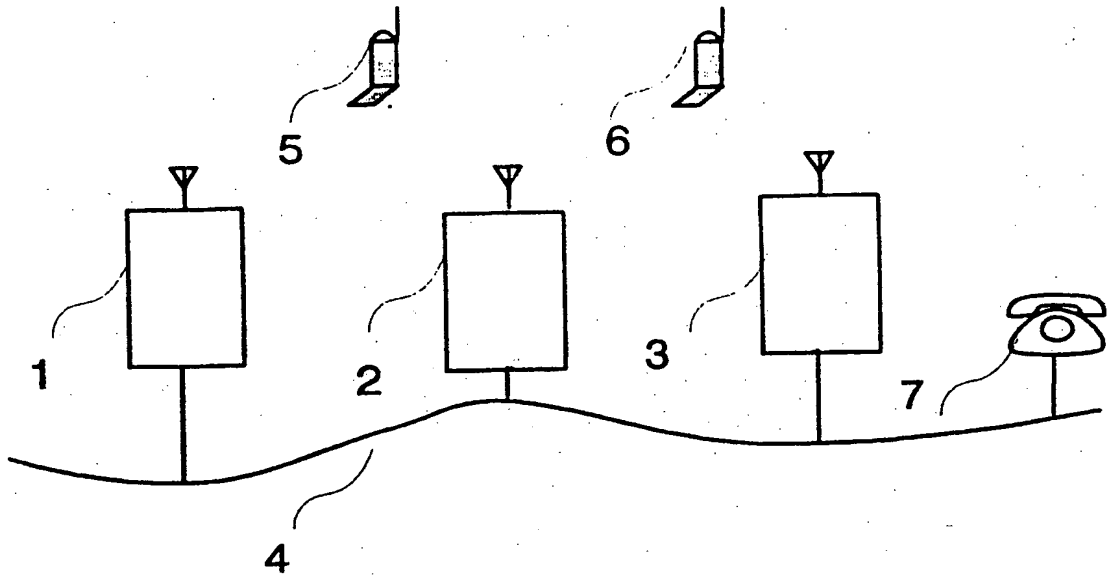


Fig.1a

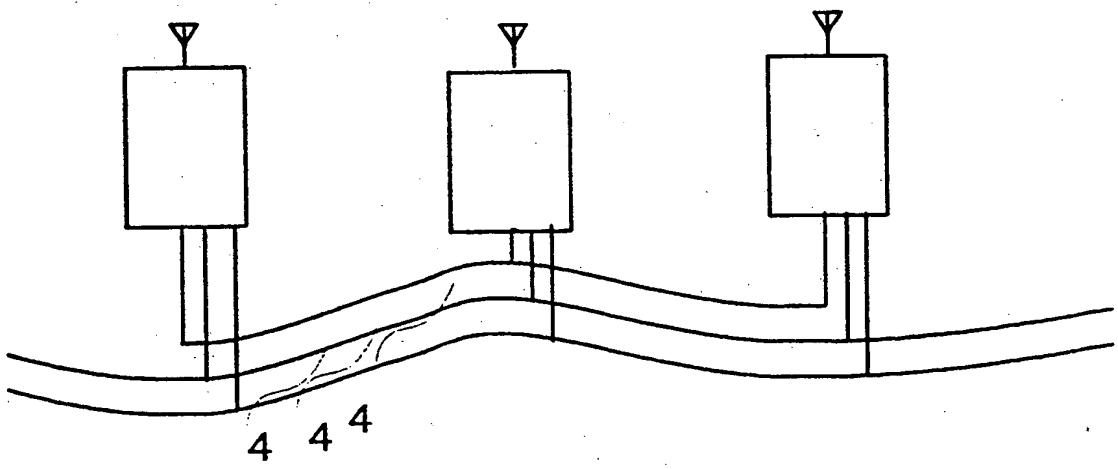


Fig.1b

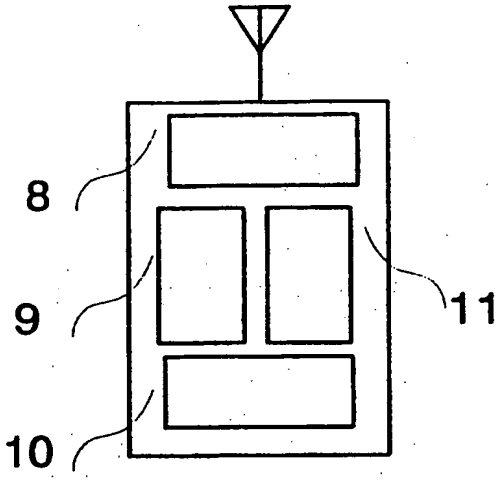


Fig.2

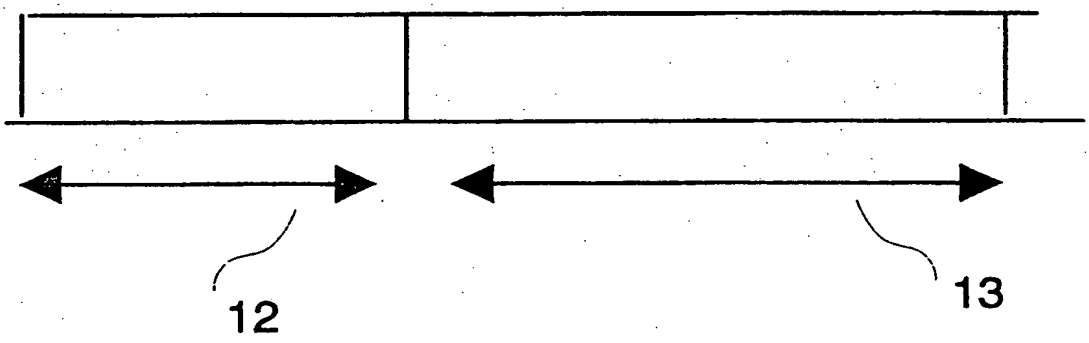


Fig.3

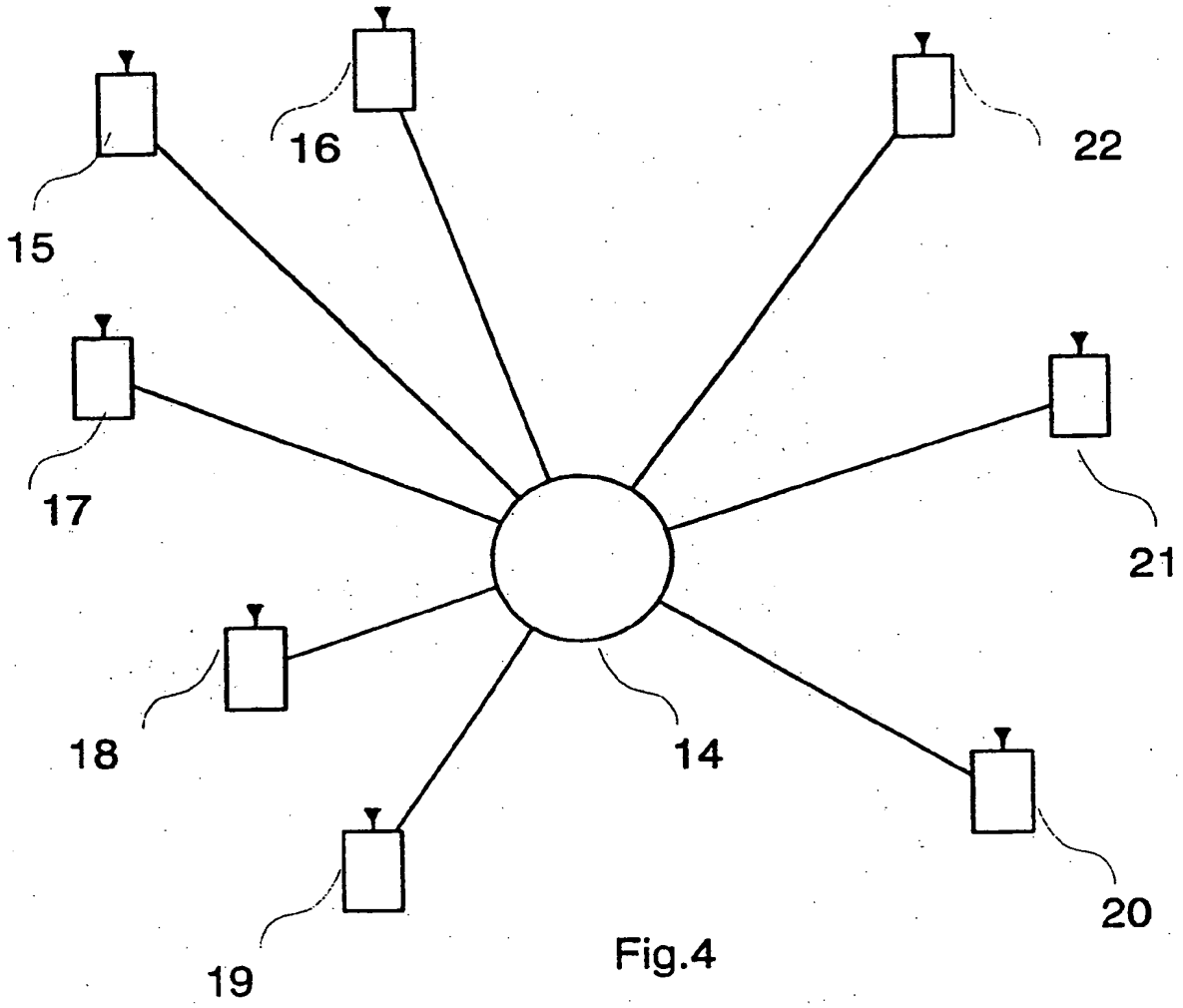


Fig.4

This Page Blank (usp